Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	GN Docket No. 14-177
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	IB Docket No. 15-256
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	RM-11664
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	WT Docket No. 10-112
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	IB Docket No. 97-95

REPLY COMMENTS OF GOOGLE INC. AND GOOGLE FIBER INC.

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The millimeter wave bands at issue in this proceeding each have significantly different physical characteristics and each presents a different incumbent-user environment.[1] The Commission can best promote innovation and intensive use of these frequencies by tailoring its rules for each band to account for these factors.

In the 70/80 GHz bands, the Commission should largely retain its existing regulatory framework. The current rules offer relatively barrier-free access to spectrum and are well tailored to the physical characteristics of these bands, which better support fixed point-to-point operations than wide-area mobile service.[2]

The 24 GHz band offers propagation characteristics better suited to mobile operations but also has exceptional reuse potential, due to high building loss and other sources of attenuation. Thus, while area licenses are appropriate in this band, they should be small in size. This band could also be a good candidate for deployment of Spectrum Access Systems (SASs) to further increase efficiency.[3]

A large and diverse group of commenters agree. Some, however, maintain that the Commission should adopt large, uniform license areas and legacy sharing schemes in virtually every band to support 5G investment by mobile carriers.[4] The record as a whole makes clear that this represents too narrow a view. While established carriers will surely seek to offer new services in the millimeter wave bands, and should have access

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[1] Comments of Google Inc. and Google Fiber Inc. in GN Docket No. 14-177, et al., at 1 (filed Sept. 30, 2016). Unless otherwise indicated, all comments referenced herein were filed in GN Docket No. 14-177, et al., on September 30, 2016.
[2] *Id.* at 2-6.
[3] *Id.* at 6-11.
[4] *See, e.g.,* Comments of AT&T at 5, 11-12.

to sufficient existing and new spectrum to do so, others are planning different applications such as service to, from, and between aircraft;[5] ultra-high bandwidth mesh networks;[6] and next-generation satellite Internet service.[7] The Commission can best enable the widest range of innovative new services through regulatory diversity that supports service diversity, with flexible service rules optimized for the band's technical properties—not for just a few current business models.

Finally, the Commission should remember that wireless innovation will not and should not stop with the bands identified in this one proceeding. Even if it is too early to consider detailed service rules for bands above 95 GHz, the Commission can at least stimulate the research and innovation needed to operationalize these bands by providing clarity within the current rules.

I. The Commission Should Generally Retain its Existing Rules for the 70/80 GHz Bands.

In addition to Google and Google Fiber, the vast majority of commenters support maintaining the existing light-license rules in the 70/80 GHz bands.[8] Commenters recognize that the Commission's flexible and streamlined framework provides

[5] *See, e.g.*, Comments of Aeronet Global Communications Inc. at 4-5 (filed Sept. 28, 2016); Comments of Google Inc. and Google Fiber Inc. at 2-3.
[6] Comments of Collinear Networks, Inc. at 5.
[7] *See, e.g.,* Comments of the Boeing Company.
[8] *See* Comments of 5G Americas at 7; Comments of Anova Technologies, LLC at 2-3, 6-7; Comments of Collinear Networks, Inc. at 6-11; Comments of CTIA at 3, 14-16; Comments of the Dynamic Spectrum Alliance at 8-9; Comments of Ericsson at 13-15; Comments of Fastback Networks at 3; Comments of Micronet Communications, Inc. at 3-4; Comments of Mobile Future at 4-5; Comments of NEC Corporation of America at 2 (filed Sept. 29, 2016); Comments of Qualcomm Incorporated at 12; Comments of the Telecommunications Industry Association at 14-15; Comments of Wi-Fi Alliance at 6-7.

significant benefits for a variety of different use cases. The link registration system, in particular, is well-suited to these bands. Because signal propagation is limited, the 70/80 GHz bands are naturally suited for highly directional applications such as point-to-point links. At the same time, the Commission's light licensing and link registration process offer low barriers to entry, ensuring that unnecessary regulatory hurdles do not stifle new applications.

The Commission can improve upon these existing rules by better accommodating dynamic beamforming for point-to-multipoint applications and aligning antenna requirements with international standards. Specifically, the Commission should permit 70/80 GHz licensees optionally to register polygons containing the endpoints of any potential point-to-multipoint links instead of requiring licensees to register numerous individual point-to-point links,[9] and also lower minimum antenna gain to 38 dBi.[10]

As noted in our initial comments, Google and Google Fiber have registered 70/80 GHz links for a number of purposes, among them providing the wireless broadband services of Webpass, Inc. Maintaining the existing regulatory framework would continue to provide ease of market entry for such high-speed, point-to-point, or short-range applications, while also allowing further innovation.

[9] Comments of Google Inc. and Google Fiber Inc. at 4-5.
[10] *Id.* at 5.

Multiple commenters highlight the 70/80 GHz bands' potential role in expanding backhaul capacity to meet the demands of mobile and other services.[11] Their submissions suggest that these bands can be part of the answer to Chairman Wheeler's calls to increase capacity and competition in the market for backhaul services so that 5G small cells and other new broadband services can be connected to the wider Internet.[12] In addition to traditional fiber connections, 5G and other future innovations will likely increase demand for high-bandwidth, low latency wireless backhaul as well. The 70/80 GHz bands, under current rules, are well situated to fill this need and, due to the relatively low barriers to entry under the current framework, could offer a robust new source of competition in the market for backhaul services.

II. The Commission Should Foster More Efficient Use of the 24 GHz Band Through Smaller License Areas, and Consider SAS Management.

Unlike the 70/80 GHz bands, the 24 GHz band is very suitable for a range of small-cell mobile operations.[13] As the Open Technology Institute and Public Knowledge point out, 30 GHz "is generally considered the breakpoint for radio signal penetration

[11] *See* Comments of 5G Americas at 6; Comments of Ericsson at 13-14; Comments of NEC Corporation of America at 1.
[12] Prepared Remarks of Tom Wheeler, Chairman, Federal Communications Commission, *The Future of Wireless: A Vision for U.S. Leadership in a 5G World* (June 20, 2016), http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0620/DOC-339920A1.pdf.
[13] *See, e.g.*, Comments of the Dynamic Spectrum Alliance at 3, 7-9 (urging the Commission to use a SAS-based system to allow mobile use at 24 GHz, but to leave the 70/80 GHz rules unchanged); Comments of FiberTower Spectrum Holdings, LLC at 2-3 (urging the Commission to permit mobile use in the 24 GHz band); Comments of AT&T at 9 (explaining that the 24 GHz band, among others, will be valuable for 5G mobile service); Comments of Verizon at 3 (urging the Commission to open the 24 GHz band, among others, to mobile use).

through an outer wall, foliage and/or precipitation,"[14] which makes mobile uses viable. At the same time, however, the 24 GHz band is sufficiently high-frequency that its propagation characteristics will result in far smaller coverage areas than in lower frequencies. The default Partial-Economic-Area-based (PEA) licensing under the Commission's Part 30 Upper Microwave Flexible Use Service (UMFUS) therefore would require entities to claim areas much larger than a licensee could cover even with several 24 GHz base stations. This would distort the market for 24 GHz spectrum by forcing would-be users of the spectrum to bid on the right to operate across a geographic area significantly larger than what they actually wish to serve.[15] Exclusive licensing of these areas, as some have proposed,[16] would exacerbate the problem by prohibiting services that could be interleaved on a geographic basis without causing interference.

Theoretically, a licensee could choose to partition its too-large license area and offer its unused spectrum on the secondary market. But the costs of reaching such agreements, and profit-taking by initial licensees, would reduce economic efficiency and increase costs for operators compared to the alternative of establishing smaller license areas. The Commission should avoid this outcome by choosing an initial license area closer in size to operators' likely service areas—such as a census tract—which would

[14] Comments of Open Technology Institute at New America and Public Knowledge at 15 (citing *Technical Feasibility of IMT in Bands above 6 GHz*, Report ITU-R M.2376-0 (July 2015)).
[15] Conversely, smaller license areas need not interfere with the development of wider area networks. *See, e.g.,* Comments of AT&T at 13. Those seeking to operate over larger areas would remain free to acquire multiple geographically contiguous licenses.
[16] *See, e.g.*, Comments of CTIA at 8-12; Comments of T-Mobile USA, Inc. at 33; Comments of AT&T at 11-12.

achieve a distribution of spectral resources much closer to the distribution that would eventually arise through the secondary market, but at lower cost.

There are good reasons for 24 GHz license areas to be smaller in size than those in the 28 GHz band, which the Commission chose to license on a PEA-basis.[17] Although the two bands have similar propagation characteristics, the Commission chose PEAs for the 28 GHz band primarily to accommodate the license areas of existing LMDS licensees, not to account for the physical properties of the band.[18] By contrast, the 24 GHz band has few incumbent fixed licensees, and those incumbents generally received licenses to operate in areas larger than PEAs.[19] Accordingly, in the 24 GHz band, a small license area, such as a census tract, would be no less consistent with the existing license scheme than PEA-based licensing.

As several commenters have pointed out, the Commission could also use a SAS to promote open access to the 24 GHz band while protecting incumbents.[20] A three-tiered, SAS-managed licensing approach could further increase efficiency and lower barriers to entry by making 24 GHz spectrum available to other operators when it is not in active use by a licensee with priority. It would also permit continued improvement in technologies for preventing harmful interference between licensees

[17] *In the Matter of Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al.*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd. 8014, ¶¶ 30, 35 (2016).
[18] *Id.* ¶ 28.
[19] *Id.* ¶ 379.
[20] *See* Comments of the Dynamic Spectrum Alliance at 2-3; Comments of Microsoft Corporation at 11-13; Comments of Open Technology Institute at New America and Public Knowledge at 15-16.

(including incumbent services), reducing physical separation distances and, accordingly, intensifying spectrum use.

III. The Commission Should Take Steps to Encourage Innovation in Bands Above 95 GHz.

As the Commission finalizes new rules for today's spectrum frontier, it should also begin to lay the groundwork for exploring the next one. In addition to final service rules in the bands identified in the NPRM and FNPRM, the Commission should also consider clarifying its regulatory approach for spectrum above 95 GHz. Marcus Spectrum Solutions has pointed out a lack of clarity about the Commission's regulatory treatment of these bands. Clarification on issues such as radiofrequency exposure rules and protection of existing passive services would improve predictability and assist researchers, businesses, and investors who are considering technologies capable of using these bands for communications or other purposes.[21] Uncertainty not only delays the availability of technologies that will use these bands, but also reduces the likelihood that research will yield concepts that are usable at lower frequencies.[22] The Commission therefore should take steps to clarify its rules above 95 GHz even in the absence of specific proposals for the use of particular frequency bands.

[21] *See* Comments of Marcus Spectrum Solutions, LLC at 3 (filed Sept. 30, 2016).
[22] *See id.* at 8-9.

IV. The Commission Generally Should Adopt Spectrum Policies that Are Likely to Encourage and Support New Services in These Bands.

Virtually all commenters agree that the millimeter-wave bands offer an exciting opportunity for the Commission to kick-start a new wave of wireless innovation.[23] Accordingly, as discussed above, the Commission's top priority should be designing rules to support the broadest possible range of services, while avoiding the pitfall of presupposing a particular business model for wireless service.

A number of commenters, for instance, highlight the potential role of airborne applications in the 5G device and service ecosystem.[24] For the 70/80 GHz bands, in particular, commenters made clear that aeronautical applications are more than a possibility: Manufacturers and operators have concrete plans to use these bands. Aeronet, for example, has "already completed architecture design work and the expected validating results from [those] tests" for gigabit-class connectivity to, from, and between moving aircraft.[25] And as explained in our opening comments, Google itself has registered 70/80 GHz links to support the development of Project Loon's balloon-powered Internet service.

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[23] *See, e.g.*, Comments of CTIA at 3; Comments of Wi-Fi Alliance at 1-2; Comments of Open Technology Institute at New America and Public Knowledge at 4; Comments of Huawei Technologies, Inc. (USA) and Huawei Technologies Co., Ltd. at 2; Comments of AT&T at 2; Comments of Qualcomm Incorporated at 1; Comments of Competitive Carriers Association at 2; Comments of Samsung Electronics America, Inc. and Samsung Research America at 1-2; Comments of the Consumer Technology Association f/k/a The Consumer Electronics Association at 1-3; Comments of the Telecommunications Industry Association at 2.

[24] *See* Comments of Collinear Networks, Inc. at 10; Comments of the Boeing Company at 54-55; Comments of the Fixed Wireless Communications Coalition at 3, 9; Comments of Wi-Fi Alliance at 9-10; Comments of Aeronet Global Communications Inc. at 4-5.

[25] Comments of Aeronet Global Communications Inc. at 5.

Such airborne and aeronautical applications are simply examples of the possibilities offered by the millimeter-wave bands. The Commission should ensure that its new rules for these bands can support airborne services and other new classes of service beyond what we can imagine today.

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